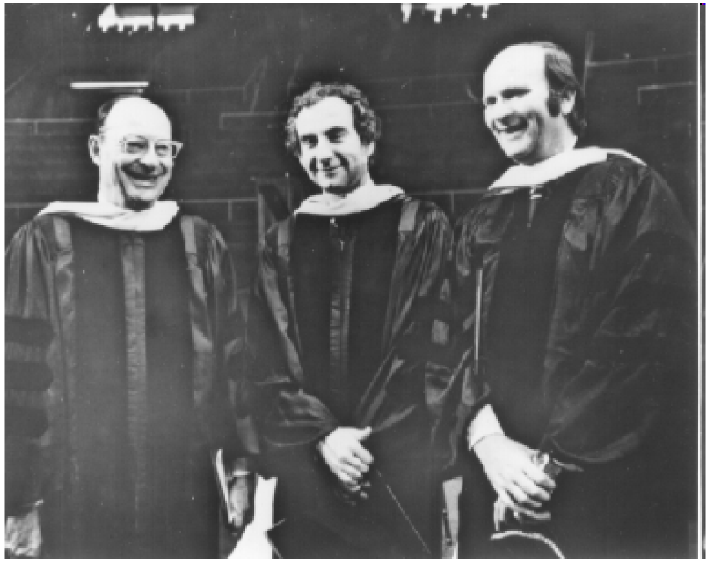
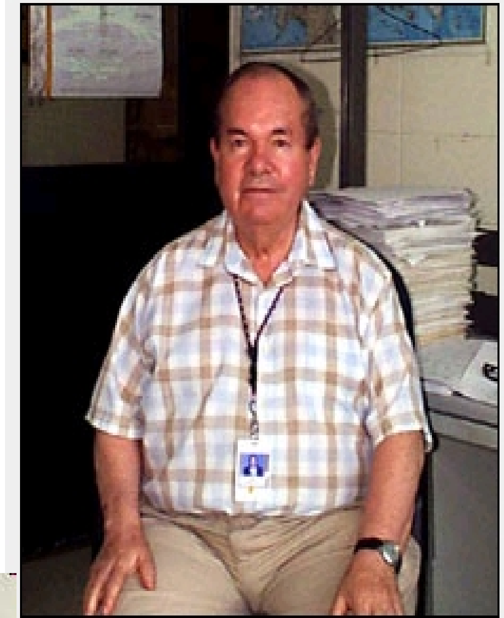
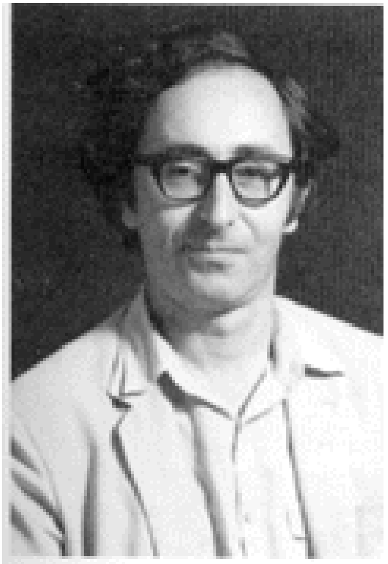
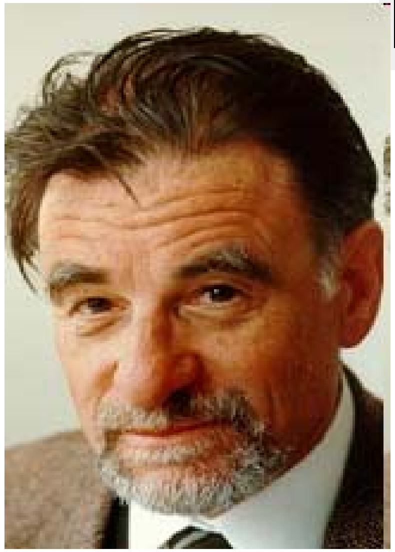
Magnetismo e Superconduttività

Gruppo NMR-NQR
http://arturo.unipv.it

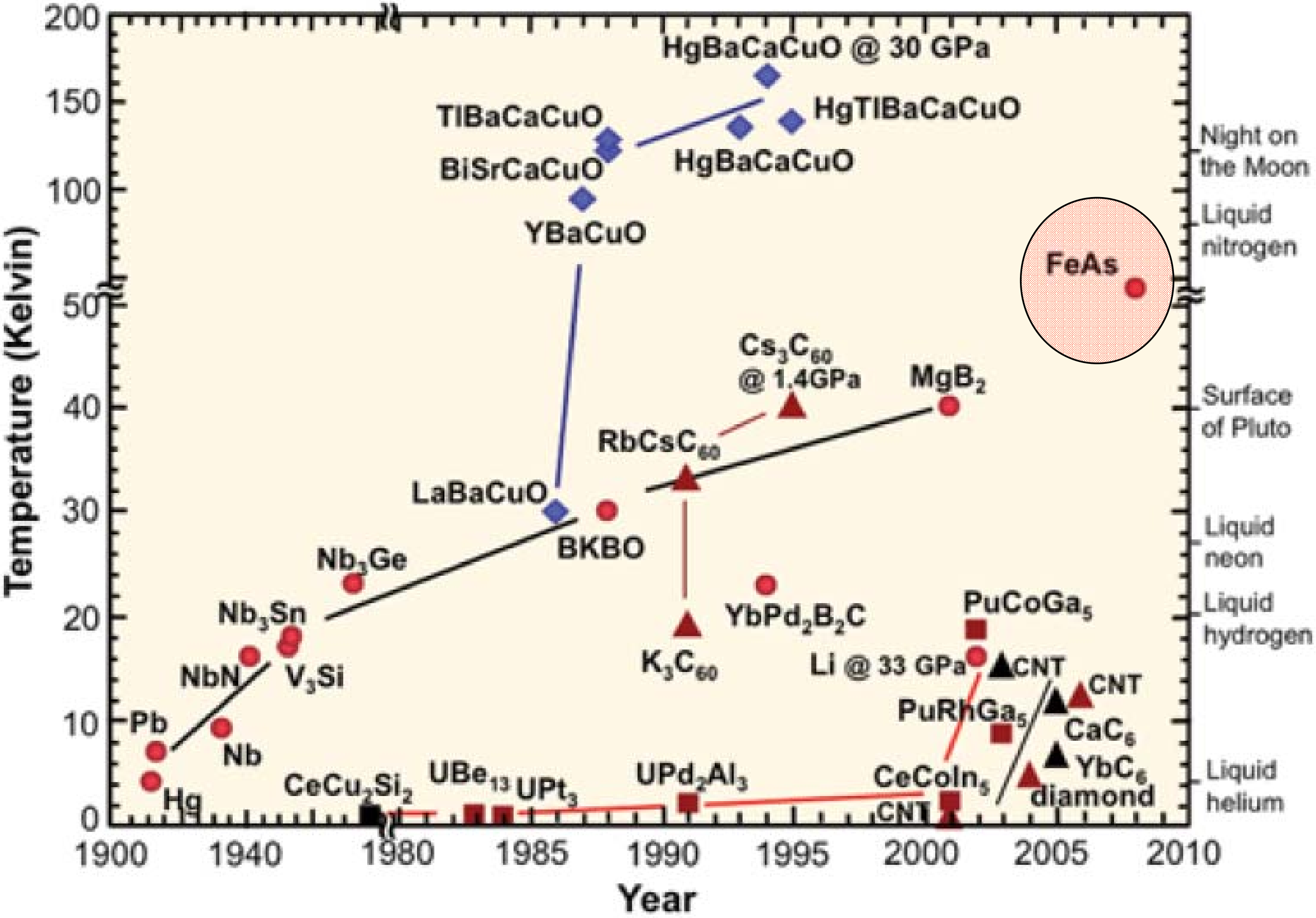
A bit of history…

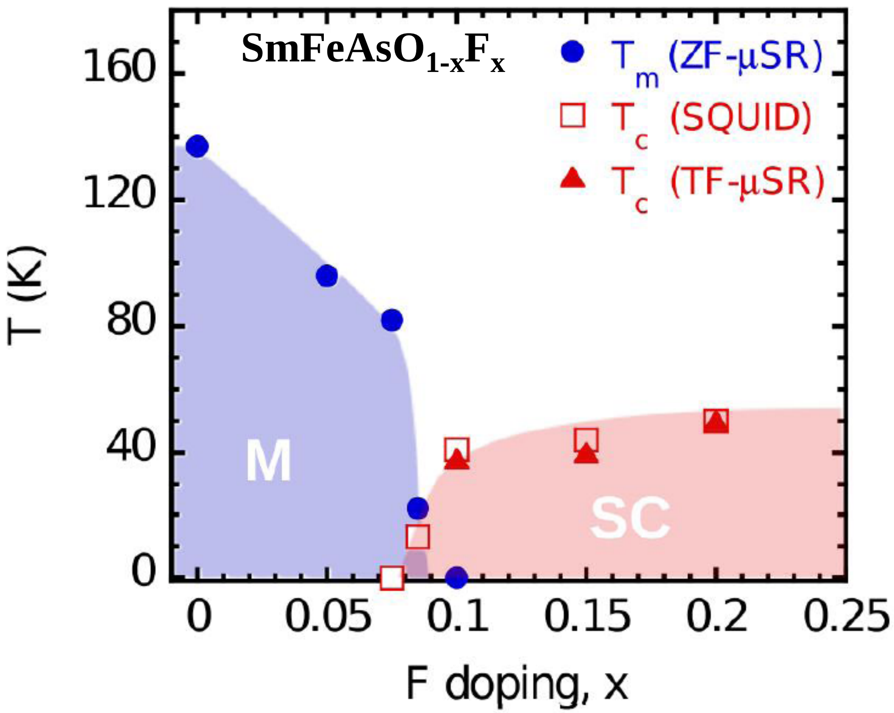



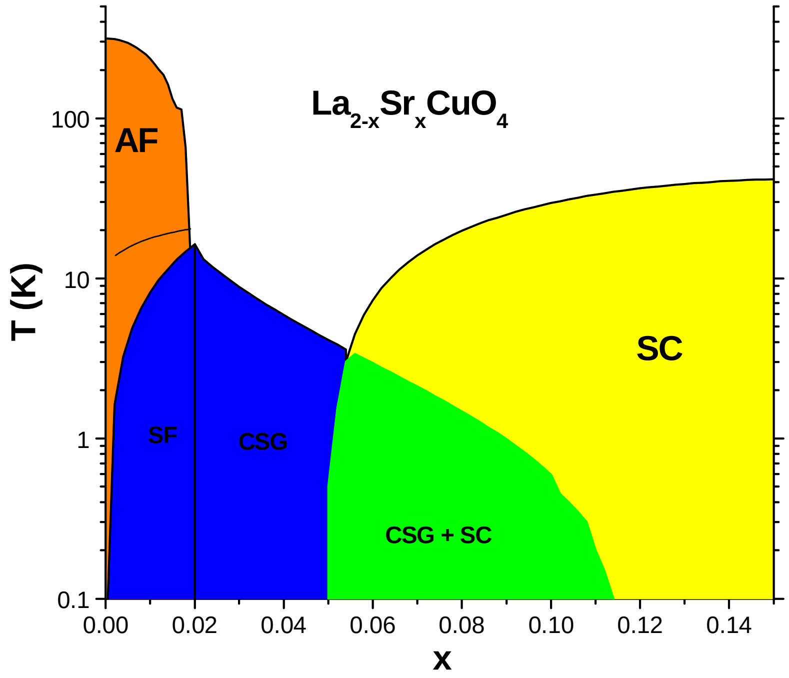

http://www.superconductivity.eu

A bit of history…



Pnictides-Cuprates Superconductors Phase Diagram

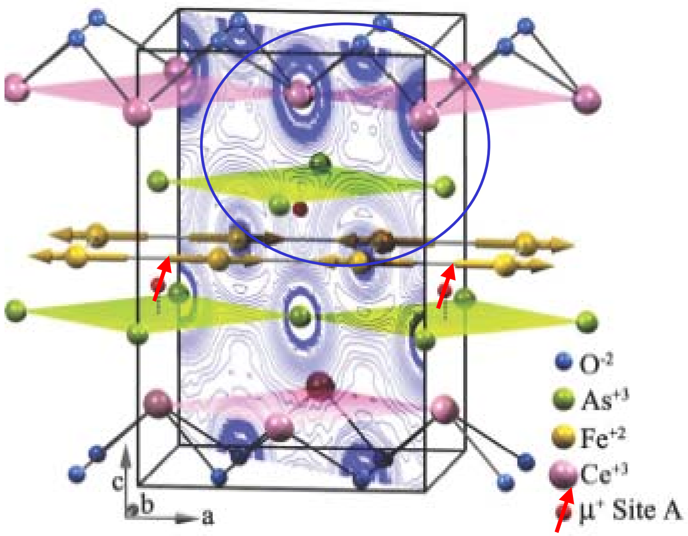




- **Phase Diagram: Competing Phases →New Phases, Quantum Phase Transitions**
- **Normal State Excitations →Pairing Mechanism**

Nanoscopic coexistence of Magnetism and Superconductivity in Fe-based superconductors

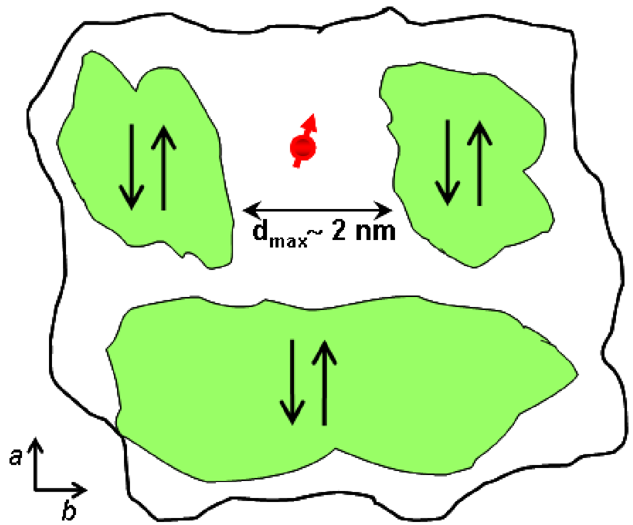
$REFeAsO_{1-x}F_x$



μ^+ (S=1/2)

range of hyperfine interaction ~1 nm

⇒ *local probe*



All the muons detect *static* magnetic moments if the *maximum distance* between AF magnetic domains is ~2-4 nm

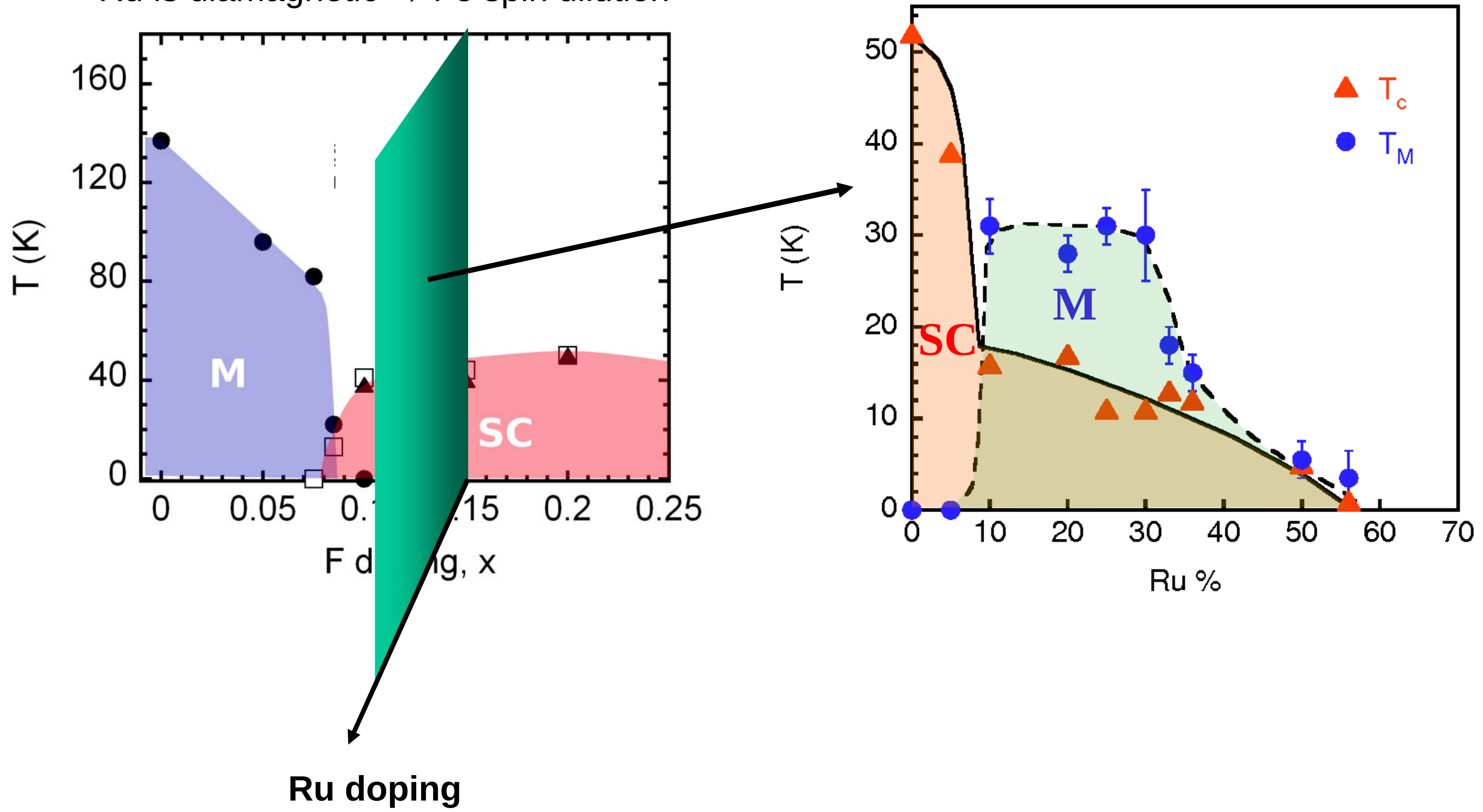
Ru doping of superconducting RE1111

Ru is isoelectronic to Fe ⇒ no charge doping

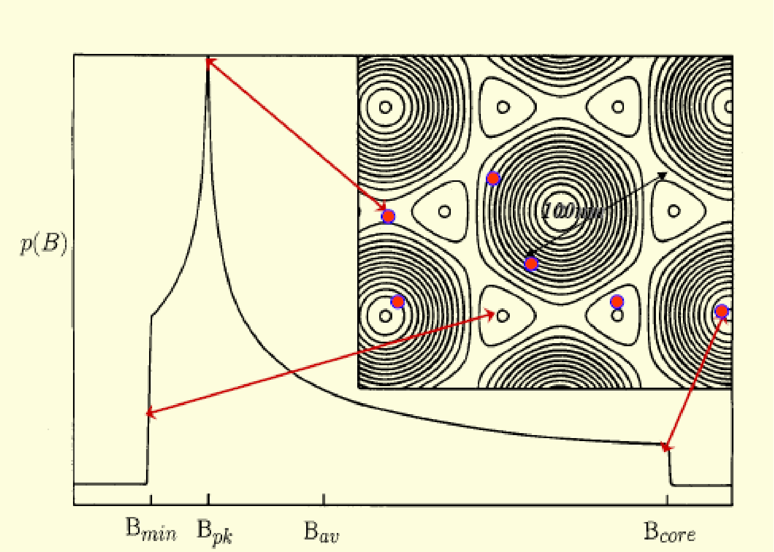
Ru is diamagnetic ⇒ Fe spin dilution

$SmFe_{1-x}Ru_xAsO_{0.85}F_{0.15}$

Sanna et al, PRL107, 227003 (2011)

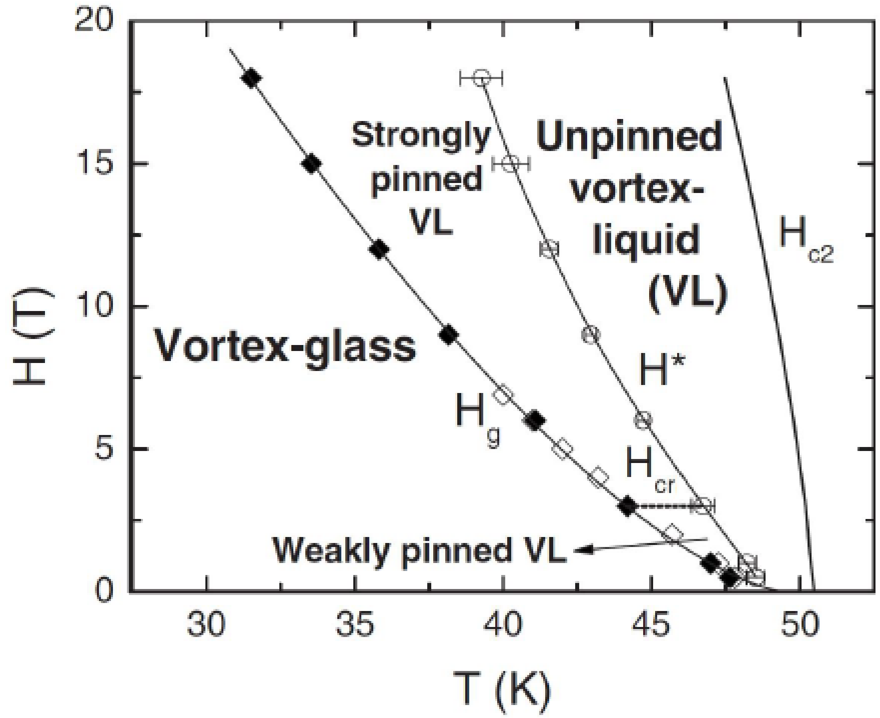


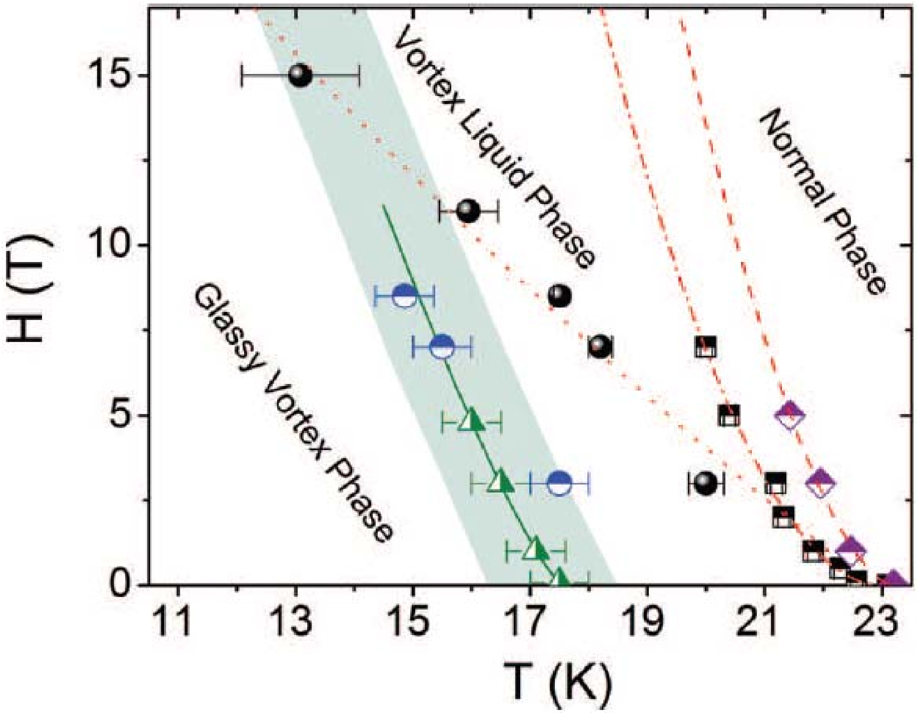
Flux Lines Lattice Phse Diagram



Cuprate SC

Fe-based SC



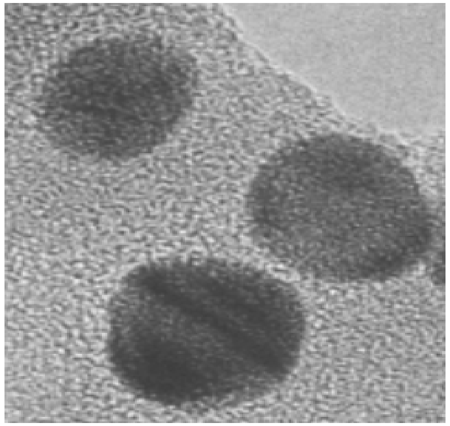


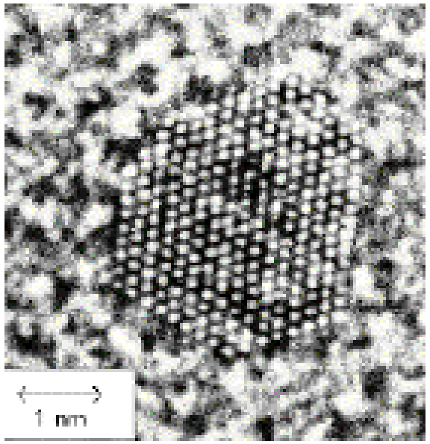
Magnetic Nanostructures

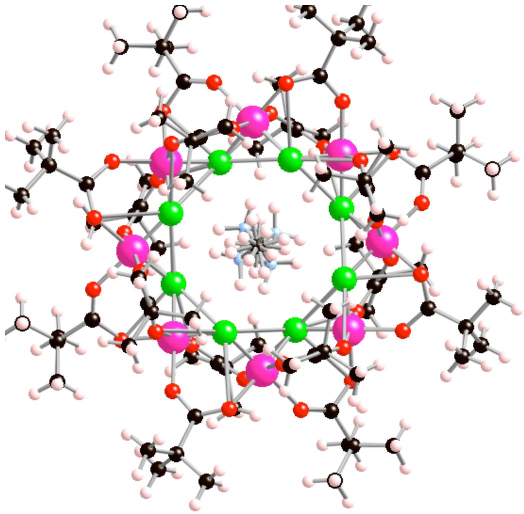
Nanoparticles clusters molecular nanomagnets atoms

10^5 - 2 10^3-10 20-1 0.1 (nm)

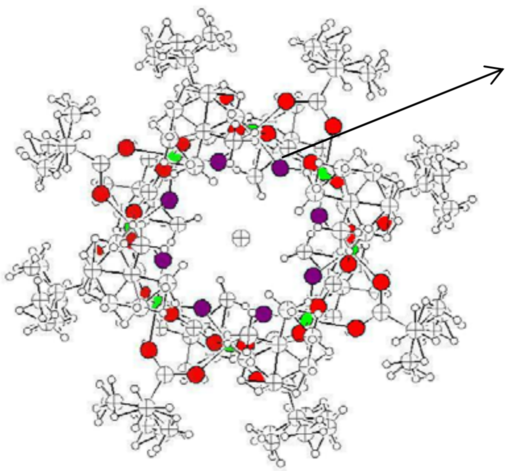
30 nm 5 nm ~1 nm





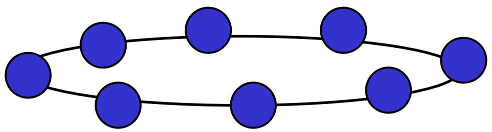


0D Magnetism from Molecular Magnet + Impurity

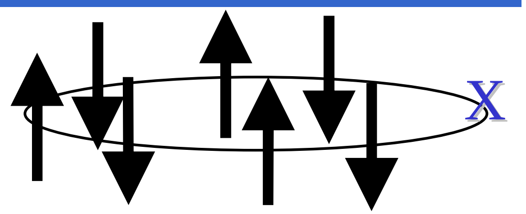


Cr(III) s = 3/2
AF ground state
(total spin $S_T = 0$)

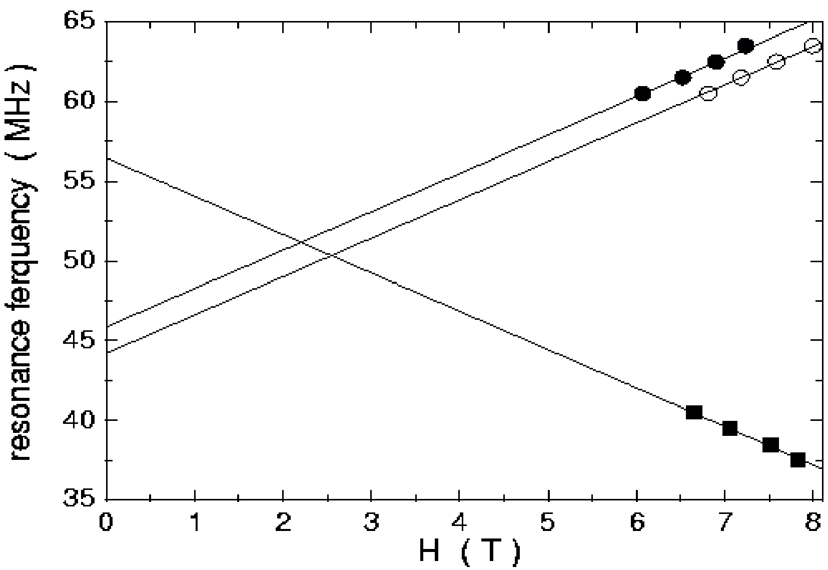
$J \approx 17.2$ K
$\Delta_{0\rightarrow 1} \approx 9.4$ K

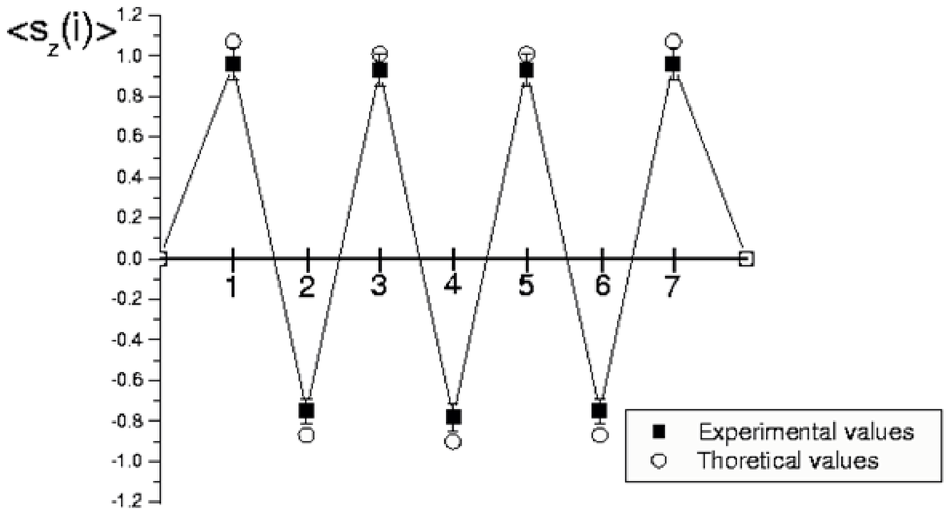


Cr8 S=0



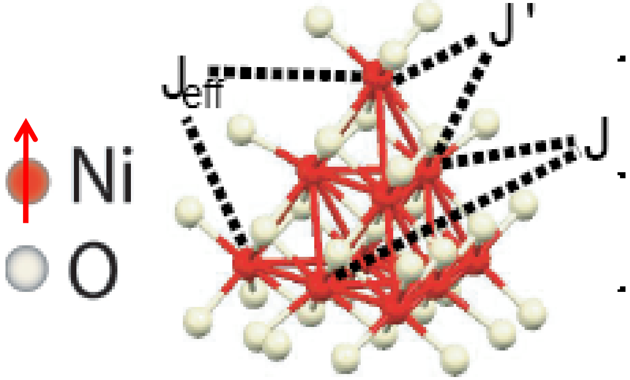
Cr7Cd S=3/2





Phonon Trapping in Ni10

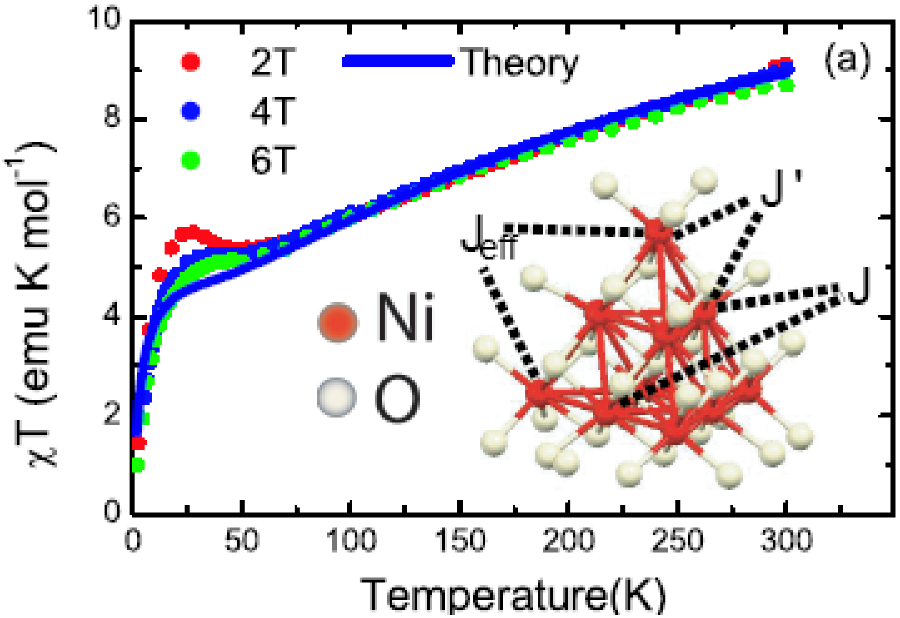
Ni10

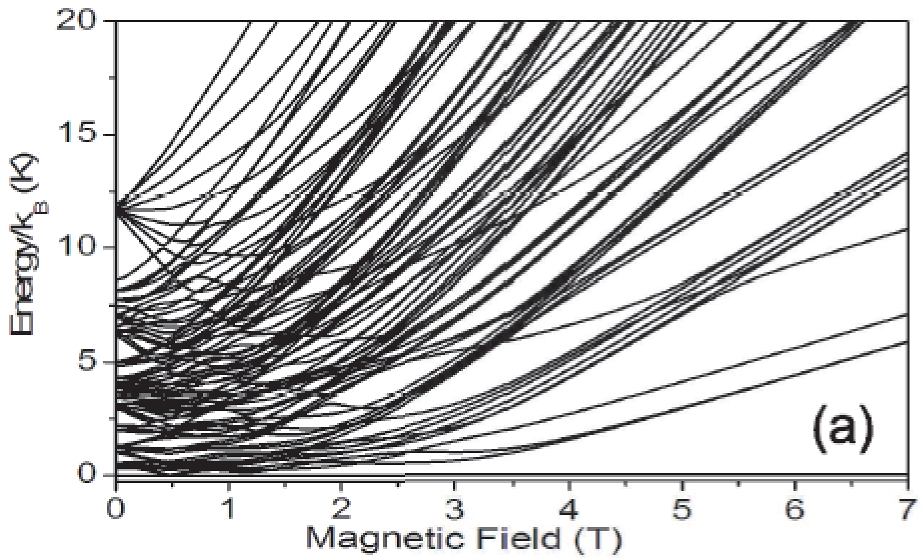


$$H_{eff} = J_{eff}/2 \sum_{i \neq j = 1,4} \mathbf{s}_i \cdot \mathbf{s}_j$$

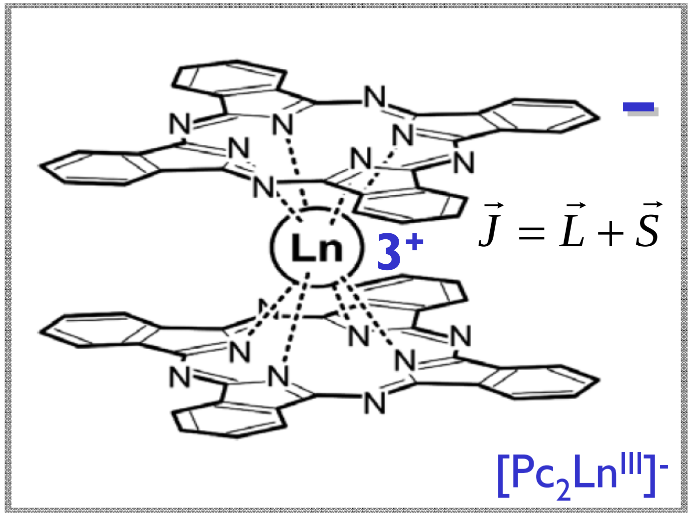
J'=12.8K J=170K , $J_{eff} \propto J'^2/J$

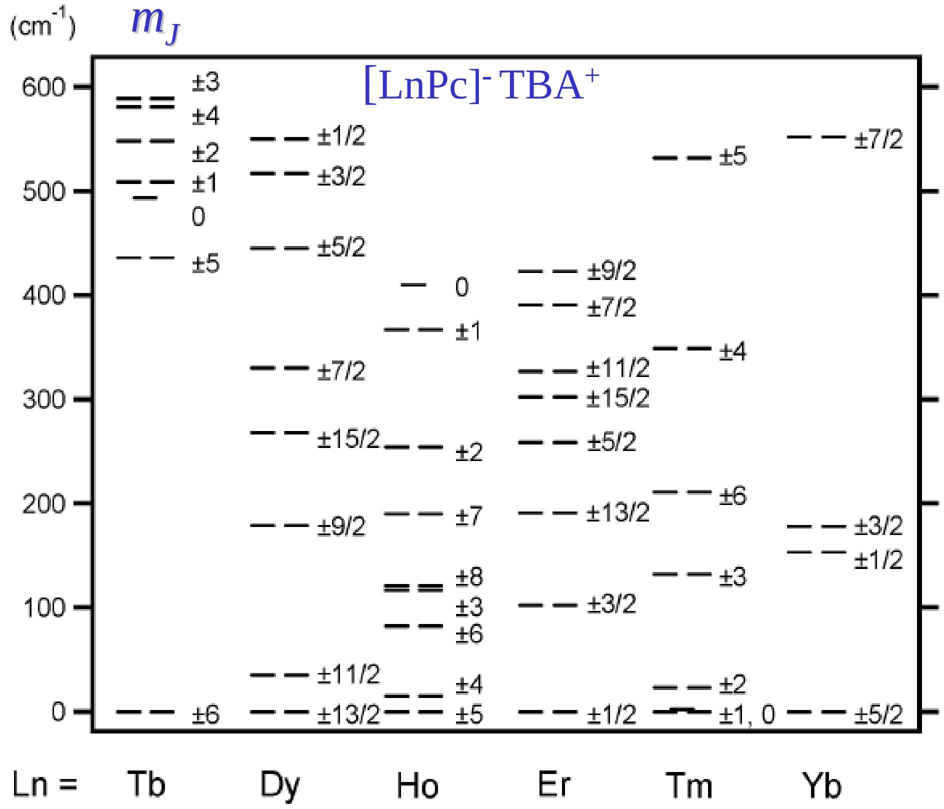
Lowest energy band H_{eff}
(almost continuum of levels):

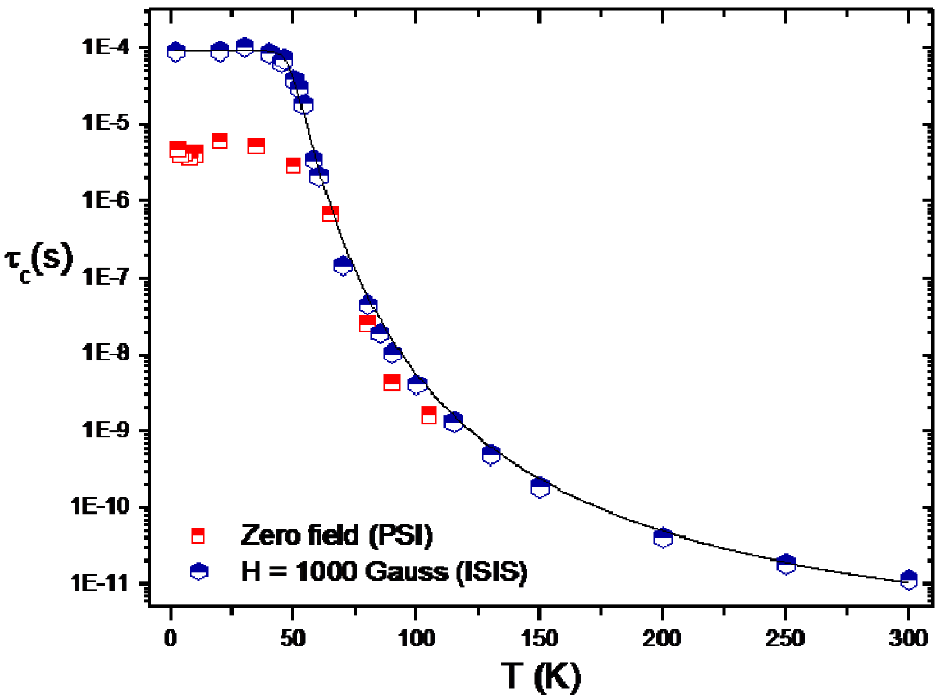




Highly Anisotropic Single Molecule Magnets



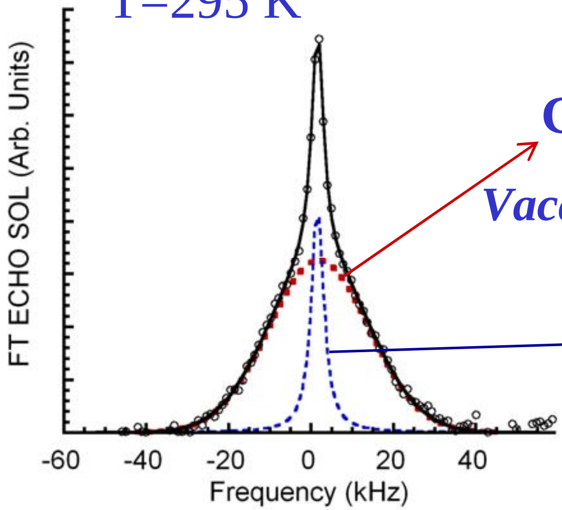




Energy - Hydrogen Storage in Carbon based Materials

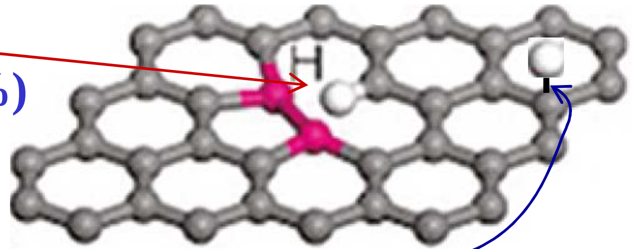
NMR spectrum for H-enriched defective graphene

T=295 K



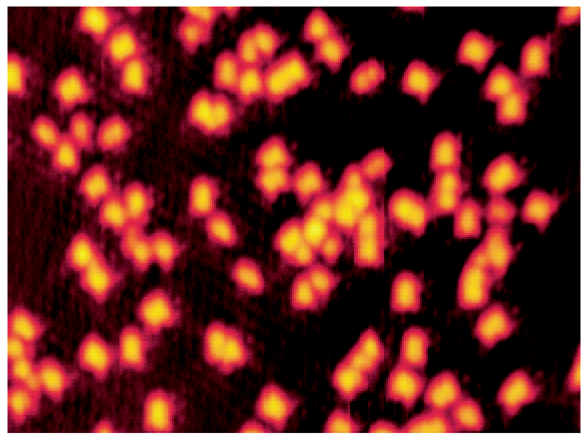
Gaussian

***Vacancy and edge-H* (~75%)**

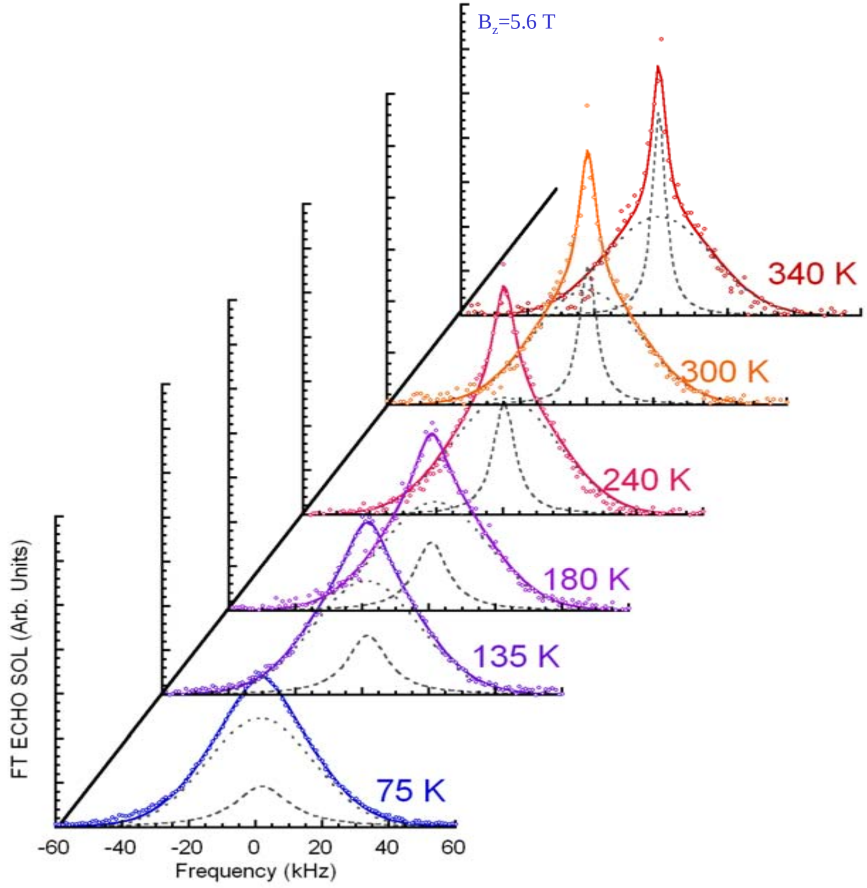


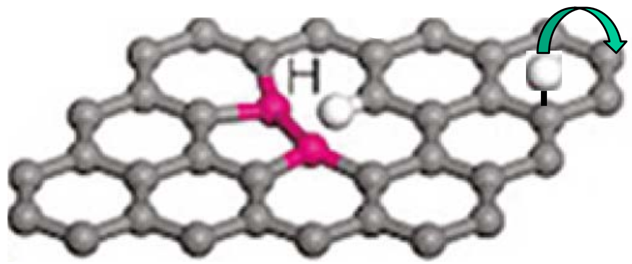
Lorentzian

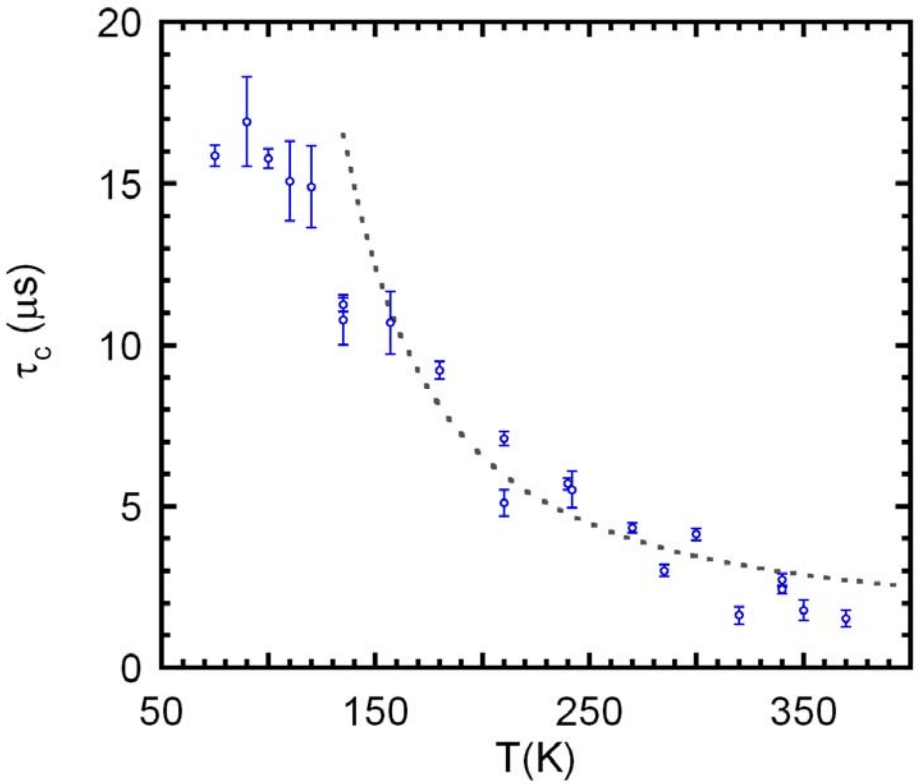
***In-plane adatom H* (25%)**



Hydrogen Storage in Carbon based Materials







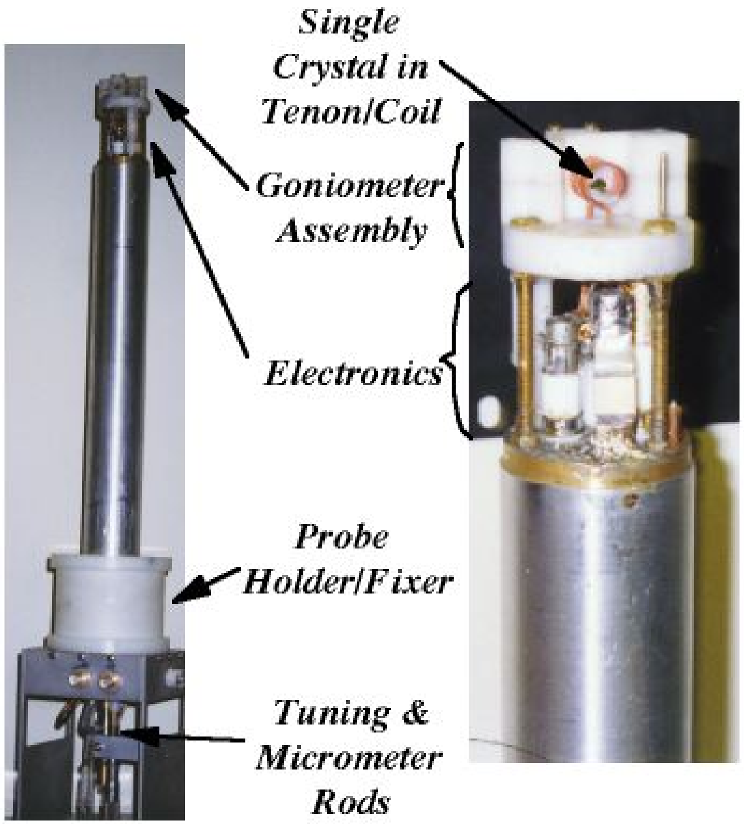
Principali linee di Ricerca

- **Superconduttori a base di Fe e organici (PAHC)**
    1. Meccanismi di formazione delle coppie di Cooper
    2. Eccitazioni nella fase normale
    3. Diagrammi di fase
    4. Dinamica delle linee di Flusso
- **Magneti molecolari**
    1. Stato fondamentale di magneti 0D
    2. Tempi di decoerenza – processi di tunneling
    3. Accoppiamento in cavità e in conduttori organici
- **Stoccaggio dell'Idrogeno in materiali a base di Carbonio**
    1. Tempi di diffusione dell'idrogeno e barriere d'attivazione in Grafene e Fulleriti
- **Nuove Fasi della Materia: Spin Ice, Spin Nematic, etc…**

Tecniche Sperimentali

(http://arturo.unipv.it/NMR/equipment.htm)

- **Risonanza Magnetica e di Quadrupolo Nucleare (NMR e NQR)**
  - 3 Spettrometri a Larga Banda (5-450 MHz)
  - Magneti 0 - 9 Tesla
  - 400 mK< T <1000 K
  - 1 bar < P < 10 kbar



Tecniche Sperimentali

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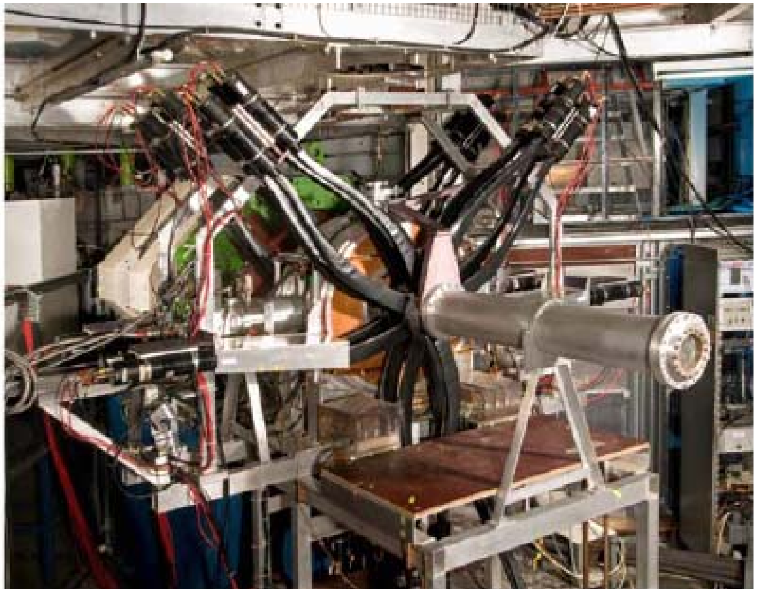
- **Risonanza di spin del muone (μSR)**
  - ISIS Facility at RAL (UK) - http://www.isis.stfc.ac.uk/groups/Muons/
  - PSI –Swiss Muon Source - http://lmu.web.psi.ch/
- **Magnetometria SQUID, misure di trasporto, calorimetria**
  - 0 < H < 7 Tesla
  - 2 K < T < 600 K
  - 1 bar < P < 12 kbar



People (nome.cognome@unipv.it)

(http://arturo.unipv.it/NMR/people.htm)

- **Permanent Staff**
  - Pietro Carretta
  - Maurizio Corti
  - Alessandro Lascialfari
  - Samuele Sanna
  - Marco Moscardini
- **Post-docs**
  - Marta Filibian
  - Franziska Hammerath
  - Lorenzo Bordonali
- **PhD students**
  - Lucia Bossoni
  - Tomas Orlando
  - Awni Al-Hourani
  - Fatemeh Adelnia
- **Undergraduate**
  - Alessio Gaimarri